Some thoughts on Chapter on Sound, in NCERT new Science Textbook for class 9

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Reading this chapter left me with mixed emotions. I did get a sense that writers of the chapter tried their best to write a chapter that, in their opinion, was an improvement over the way the concept of sound is presented in current science textbooks. Surely, they are to be commended for their efforts. However, I also had a feeling that as part of an effort by the mainstream educational system to improve science textbooks, these writers suffered serious constraints in their abilities to conceive as well as execute major improvements (and alternative ideas about textbooks) in their efforts. I think it would be unfair to blame them for these constraints. But, we, who are on the margins, can certainly critique the output so as to reveal these constraints, and understand how things could be otherwise.

In this review, I approach the chapter on sound as a tool for learning, and thus try to understand what it offers to students[1]. That is, from a learning perspective, I explore what understandings and impressions of: (a) the concept of sound in particular, and (b) science (and nature of science) in general, would a student take home with her after having been taught this chapter at school.

<u>So what's in it for a student?</u>

Before I go ahead, a caveat is in order. Critiquing this chapter from a learning perspective involves making a dangerous and simplistic assumption about who is this student we are talking about. As we all know, national level curricula and textbook making efforts suffer from a major limitation of being written for a stereotypical student body that may well exist only in the imagination of the writers. Students comprise an extremely diverse population group. The differences between rural and urban students are, in particular, vast and acute. However, since I am critiquing a chapter written for a fictitious group of students, I realize I can't help but make such an assumption about students myself.

(A) What a student may be able to learn about the concept of sound from this chapter?

The learning goals for the chapter as inferred from the opening paragraph are three: (a) how sound is produced; (b) how it is transmitted through a medium; and (c) how it is received by our ear. The chapter is designed to meet these learning goals with the help of lots of descriptive text (about 11-12 pages) and a bunch of suggested activities related to it. Ideally speaking, a concept should be taught with the help of at least three different kinds of curriculum material, viz. teacher's guide, student manual (for description of activities and experiments, and recording and analysis of data), and textbook that describes and illustrates the concept and links it with other concepts, experiences, data and the wider world. All these three different materials have different roles and deserve to be kept separate from each other. Since NCERT textbooks combine all three materials into one book, role of each category of curriculum material gets severely compromised. For instance, the chapter starts in a pretty nice way by setting the stage for learning about sound with two suggested activities (12.1 and 12.2). I was very please to see that both these activities invite students to discuss among themselves the reasons behind the phenomena they see in these activities. However, since the succeeding text explains the phenomena, much of the rationale of doing the activities is lost. I know this is a common problem with all other experiments in this chapter and probably in other chapters too. However, these two activities are different from the others in this chapter in the sense that here the explanation follows the activities and not vice versa. In all other activities in this chapter, description and explanation of phenomena precedes the suggested activity. Thus, either by design or constraints (of having a single text for all purposes), activities are reduced to illustrate the concepts described in the text. This robs from them (the activities, I mean) a much more crucial role of being the launching pads of students' own explorations into the concept of sound, and helping them construct their own (yet scientifically correct) understanding. Thus, what students will take home with them by doing the experiments is probably a

[1] A parallel analysis of the chapter can be done to critique this chapter as a tool for teaching in terms of affordances and constraints it provides to a teacher aiming to teach the concept of sound.

better recall of the phenomena, and a realization that science is an authoritative body of (textual) knowledge that can be verified by doing experiments. Here I should clarify that I am not against use of experiments to see/test the validity of previously made scientific statements (i.e. scientific knowledge in textbooks). But as I understand, another and pedagogically more important role of experiments is testing of hypotheses and formation of scientific claims on empirical basis, i.e. generation of new (for students that is) knowledge. NCERT book and certainly this chapter can be faulted for using experiments exclusively for the former role.

Since activities perform a relatively minor pedagogic function in this chapter, I should perhaps move on to the review of the textual material on sound in this chapter. However, before doing so I must make some brief comments about the other three activities in this chapter. Activity 12.3 asks students to make a list of musical instruments and discuss with their friends which part in these instruments vibrates to produce sound. Inclusion of this activity is to be welcomed. However, this activity is clearly a copout by the writers. Perhaps, ideally they wanted students to actually play/fool around with these instruments themselves to see how vibrations in each produce sound. But not trusting the teacher to let students make a racket in class, they severely compromised their preferences and restricted the activity to making of a list. If this is really so, then it is a rather sad comment on our schools' inability to allow students learn science meaningfully and joyfully. I am also slightly apprehensive about some misunderstanding creeping in as a result of this activity as the description of this activity in the chapter implies that there is only one part in a musical instrument that vibrates to produce sound. However, there are so many instruments where vibrations are produced in more than one part of the instrument to result in the distinctive sound we hear. I also can't help but mention my misgivings about the inclusion of a demonstration to show that sound needs a medium to travel in the text (p. 162). I do not know if there are schools in India that can do this experiment in class as a matter of annual routine. Perhaps, writers realized as much and that's why this demonstration is formatted within text and not as a separate "activity". However, it is written in a way as if writers really expect teachers to do this experiment in class[2]. If writers really wanted to include this activity in a more honest way, they could have written it as a thought experiment for students to speculate upon the production of sound when air is gradually sucked out of bell jar. As for the activity 12.4 (p. 163) that purports to demonstrate propagation of sound wave with the help of a slinky, there is just a minor quibble. I am not sure if this activity can be satisfactorily performed by holding the slinky in the air (as the textbook suggests). The reason is that if the slinky is stretched tight without any sag in the middle as the associated diagrams show, it does not show compression and rarefaction that nicely. If you don't stretch it that tightly, then it will sag, and sound waves don't sag. A better alternative may be to put the slinky on a smooth table.

So now let's finally talk about the text on sound in this chapter as textual information is what this chapter really about. We do not have access to the instructions that textbook writers were given nor can we divine their intentions in writing this chapter[3]. However, from what I could infer from the design and content of the chapter is that authors wanted to convey scientific knowledge on sound through text to students. So whatever objections we may have about presenting and teaching science as text to students, if writers of the chapter wanted to write this chapter primarily as text, we should also evaluate the result of their efforts on <u>their own</u> criteria and intentions.

Now, I believe there are some thumb rules to writing clear, cogent and accessible non-fiction prose. In addition, there are also some useful guidelines for writing scientific text for non-experts, which students in grade 9 definitely are. The science text in this chapter clearly proves to be deficient in both respects. Let's first see how this text measures up as a piece of (non-fiction) prose that aims to describe and analyze a phenomenon[4]. Such a prose, I believe, should first of all clearly present a persuasive narrative that weaves all the different elements – facts, definitions, explanations, equations, formulae, diagrams and examples – into one coherent whole that both educates and inspires the reader. This narrative is generally centered around a (or few related) big idea

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[2] Since this is a demonstration to be supposedly done by the teacher, its proper place is in a teacher's guide. Thus, here we see textbook performing the role of a teacher's guide.

[3] If such information can be found, I would like to read it.

[4] The thumb rules I present below are purely borne out of my own experience and do not carry any larger validity.

that is clearly presented to the reader somewhat early in the narrative and elaborated and explained throughout the text. Also, some effort needs to be made to make the text engaging enough for the reader to make efforts to read and understand it for its own sake and not just for some external threats and incentives. There are several rhetorical tools writers use to *hook* the reader in, such as structuring the entire narrative around one big central question that an average reader can relate to and by writing the text that engages the reader in a genuine dialogue with it. Further, the main idea needs to be clearly elaborated in accessible terms and with examples that readers can relate to. The chain of reasoning should be explicit and consistent. There should also be internal consistency among descriptions of the same concept/phenomenon at different places and contexts. Lastly, in place of a clutter of incompletely developed big ideas, it is generally preferable to pick just a few ideas and develop them fully.

It is good that a reader comes to know pretty early (the first paragraph, in fact) in the chapter the three big ideas of the chapter, viz. (a) how sound is produced; (b) how it is transmitted through a medium; and (c) how it is received by our ear. However, little effort is made throughout the chapter in persuading the reader that it is worthwhile to put her energy and time in reading and understanding the chapter. For instance, the narrative is not structured around one or few central questions that may pique a reader's interest and provoke her to find their answers by reading the text. Except for one activity (12.3), it doesn't invite readers to share their own experiences regarding sound with other students and teachers. Besides experiences, students also have their own ideas about the nature of sound. It is good that activities 12.1 and 12.2 do ask students to discuss their ideas about production of sound. But that key pedagogical practice is abandoned shortly after. In short, the text talks *at* the students and not *to* the students – a trait that is pretty typical of how elders and expert talk to those junior to them in age, rank and expertise in India. Thus, I am not sure if students will like to read this chapter out of interest and without extrinsic threats and motivations.

The text lacks a strong and consistent narrative. For instance, the transitions between subtopics are abrupt and the linkage is assumed rather than explained. Reading a passage should build a sense of anticipation in the reader about what is to come next. I could never anticipate what subtopic would be presented next. How can a reader anticipate that after a discussion on speed of sound in different media (section 12.2.4), she would be confronted with a section on reflection of sound (section 12.3), or after "uses of multiple reflection of sound (section 12.3.3), she would have to read about "range of hearing" (section 12.4)? Secondly, I was not able to understand the sequence in which subtopics were presented. For instance, description of how sound travels in a medium (section 12.2) is presented before the section (12.2.1) that aims to persuade the reader that sound needs a medium to travel. Shouldn't it be the other way around? Similarly, the section 12.4 on "range of hearing" is stuck between section 12.3.3 on "uses of multiple reflection of sound" and section 12.5 on applications of ultrasound. Wouldn't it be better if it was made part of the last section 12.6 that explains how we hear? Alternatively, the writers could have presented this last section along with "range of hearing" before talking about ultrasound and uses of reflection of sound. Bereft of a sense of narrative, the text comes across a cut and paste job of related topics on sound in no particular order. If writers think that students can't sense lack of narrative in a text, then they are surely mistaken.

Even if we disregard the lack of narrative, inconsistencies in how concepts are presented in different sections can discourage even the most motivated readers. For instance, in the beginning sound is presented as a form of energy. Then without fully developing the idea of sound as energy, and without any rationale for the change, sound is presented as a disturbance or density/pressure variations that move through a medium. Finally sound is presented in its graphical form. The linkage between sound as longitudinal density/pressure variations and its graphical representation (where it starts looking like a transverse wave) is made and I have no complains about it. But I would still quibble over the detail in which properties of sound have been discussed when it is represented graphically. The reason is that I suspect that by extensive portrayal of sound in a graphical form many students end up remembering sound as a transverse wave. Also portrayal of sound as energy isn't picked up later in the text. At one place (p. 165) a connection is made between sound and energy, but in a way that may give rise to some confusion. Here it is said that "Loud sound can travel a larger distance as it is associated with higher energy". First, "associated" is a very vague word; it can have umpteen connotations. Secondly, it tells the reader that sound and energy are two distinct though related (or "associated") concepts. This certainly contradicts earlier assertion in the chapter that "sound is a form of energy" (p. 160). Similarly, on page 165, it is

said that “loudness or softness of a sound is determined by its amplitude”, whereas on the next page it is asserted that “loudness is a measure of the response of the ear to the sound”. Now which student wouldn’t get confused by reading these two apparently contradictory statements? Sometimes, the conceptual confusion becomes amusing as well. For instance, I couldn’t help but smile at reading the tautological assertion that “frequency tells us how frequently an event occurs” (p. 164).

As the chapter had three main learning goals, wouldn’t it have been better if the text developed them at length rather than also talking about *reflection of sound, sonic boom, echo, reverberation, uses of multiple reflection of sound, applications of ultrasound, and sonar.* Just imagine ... within 16 pages, the writers not only found enough space to meet their three main learning goals, but also educate students about 7 other related concepts! Production, transmission and reception of sound are such big and important ideas that one whole chapter can scarcely be adequate for all three, leave alone other topics that this chapter ventures into.

Lastly, as a science exposition text, this chapter commits the cardinal but rather prevalent sin of teaching new knowledge in an alien language. Let me explain. Scientific language evolved to facilitate efficient communication among scientists and <u>not</u> between scientists and laypersons. It also represents a distinct way of looking at the world that layperson (including students) aren’t much familiar with. This makes scientific language very different from the language we use in our daily life. Ordinarily we wouldn’t recommend anyone who doesn’t know Spanish to learn about Spain by reading a Spanish text. But essentially that’s what this chapter expects from the students. As other reviewers have also made this point, and as it gets reflected in the textbook as a whole, I wouldn’t belabor this point any further.

I can go on further, but I think it has become sufficiently clear by now that even if we judge this chapter as a piece of science writing, it suffers from weaknesses on several counts. So in response to my initial question with which I began this section, viz. *What a student may be able to learn about the concept of sound from this chapter?*, I can only conclude that a student would at best take away some loosely connected and poorly understood scientific facts, definitions, explanations and algorithms about sound from this chapter. He may also come away with an impression that *sound* is not a particularly interesting topic in science. Further, as the chapter doesn’t aim to help students successfully apply concept of sound to understand sound related events and phenomena they encounter in their daily lives, the knowledge they attain on being taught this chapter may not prove that useful or relevant for their everyday experiences.

(B) What a student may learn about science from this chapter?

This chapter not only aims to help teachers teach the concept of sound, it also offers her some understandings and impressions about science as a whole. So, let me touch upon some of these understandings and impressions about science that a student may take home with her after reading or being taught about sound with the help of this chapter.

Though I may be simplifying things a little bit, for our purposes we can say that basically there are two ways in which science can be communicated to a layperson[5]. First, as a body of associated practices that aim to construct and communicate new knowledge about the world. Second, as a body of knowledge that has been crystallized into scientific statements about the world that are no longer disputed. Scientists come across science in both of these forms. However, when science is recontextualized from lab to classroom, it is often so transformed (to fit the ‘realities’ of school-based teaching) that it gets presented to students largely in the latter way, i.e. as a body of ossified knowledge. This chapter is a good example of this tendency. I know we all agree that it is a severely deficient representation of science for students, and thus won’t overstress this point. However, I will add that even if science is presented as a text to students, it initiates students’ immersion into another body of practices about science that may have little to do with actually doing science (in terms of constructing knowledge through experiments or otherwise). This body of practices entails (to quote a few): (a) a

[5] Not being a scientist myself, I would be happy to be corrected in this characterization of science by a practicing scientist.

veneration of codified knowledge as presented in official texts; (b) respect for authority; (c) valuing problem solving over question asking; and (d) seeing oneself as fit for only learning science but not doing it. I have come to see much value in WYDWIL approach to learning. It is an acronym coined by my erstwhile advisor that says that what-you-do-is-what-you-learn[6]. Students tend to forget much of the knowledge they learn at school, but tend to retain the practices they participated in year-after-year in science (or other) classrooms. After all that's what they really did in classroom, so that's what they finally learnt.

I had planned to cover some more points in critique of this chapter, but it is 3 AM now, I have run out of steam and I had promised to send this review by 20th. Hence, I will end now with a genuine question. An exercise question on p. 166 asks, "Guess which sound has a higher pitch: guitar or car horn?" Considering that one can strike all sorts of notes on a guitar and car horns come in all types, I am just not able to make an educated guess. Answer, anyone?

(Original, Unedited version)

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[6] This acronym has no wider circulation. Only a few of my advisor's students know what it means. So please don't go around quoting it as an acceptable and much used term in educational literature.